In the Claims

1. (Original) A decoding method for retrieving information bits encoded in a printed image comprising the steps of:

receiving an input electronic image as a scanned version of the printed image;

extracting a region of interest in the image;

estimating, for said region, amount of K colorant present, denoted K_H;

obtaining, for said region, a color value;

determining the GCR used for encoding that region using K_H and said obtained color value; and

retrieving encoded information bits based on said determined GCR.

2. (Original) A decoding method, as in claim 1, wherein estimated K_H is evaluated conditional to a capacity signal K_L and a luminance signal L.

3. (Original) A decoding method, as in claim 2, further comprising deriving from said obtained RGB data the values of K_H , K_L, and L, wherein K_H is estimated from a high resolution scan, and K_L and L are estimated from a down-scaled image, respectively.

4. (Original) A decoding method, as in claim 2, wherein the capacity signal K_L and the luminance signal L are derived from said obtained color value.

5. (Original) A decoding method, as in claim 2, further comprising determining K_L by:

applying a suitable operator *S* to reduce the image from scanner resolution to the watermark resolution;

converting the obtained color values to CMY estimates; and

using said estimates to determine K-colorant amount by K_L=min(C,M,Y)

6. (Original) A decoding method, as in claim 2, further comprising determining K-capacity amount, K_L, by:

converting said obtained color values to CMY estimates;

applying a suitable operator *S* to reduce the image from scanner resolution to the watermark resolution; and

using said estimates to determine K-colorant amount by $K_L=\min(S(C),S(M),S(Y))$.

7. (Original) A decoding method, as in claim 2, wherein L is described by a linear combination of scan signals RGB, such that $L = k_1S(R) + k_2S(G) + k_3S(B)$.

8. (Original) A decoding method, as in claim 1, further comprising K_H by:

converting said obtained color values to CMY estimates;

using said CMY estimates to determine K-colorant amount at each pixel by $K = \min(C,M,Y)$; and

applying a suitable operator *S* to reduce the image from scanner resolution to the watermark resolution, $K_H = S \min(C,M,Y)$.

9. (Original) A decoding method, as in claim 8, wherein the operator *S* is a sequence of blurring filters followed by sub-sampling.

10. (Original) A decoding method, as in claim 8, further comprising converting the said obtained color values to CMY estimates by inverting scanner RGB values, such that $C=1-R$, $M=1-G$, and $Y=1-B$, such that $K_H = S \min(C,M,Y) = S[1-\max(R,G,B)]$.

11. (Original) A decoding method, as in claim 8, wherein said obtained color values are converted to CMY estimates by a 3x3 linear transformation *M* of scan RGB values followed by inverting, such that $CMY = 1 - (M \times RGB)$.

12. (Original) A decoding method, as in claim 8, further comprising calibrating the system by:

printing a set of patches of known CMY values;

scanning said patches;

determining RGB values of said patches;

building a transformation between RGB scan values and input CMY values; and

using said estimates to determine K_H such that $K_H = \min(C,M,Y)$.

13. (Original) A decoding method, as in claim 12, wherein the transformation is a 3x3 linear transformation *M* of RGB values followed by inverting, such that CMY = 1–(M x RGB).

14. (Original) A decoding method as in claim 1, wherein K_H is estimated from a high-resolution scan by a method of thresholding the scan pixels representing the printed K dots.

15. (Currently Amended) A decoding method, as in claim 10, wherein the thresholding is performed in lightness, and dark pixels are considered part of a K dot ~~K-dot~~.

16. (Currently Amended) A decoding method, as in claim 10, wherein the thresholding is performed in chroma and lightness, and dark, non-chromatic pixels are considered part of a K dot ~~K-dot~~.

17. (Original) A decoding method, as in claim 10, wherein the threshold level for K dots ~~K-dots~~ is varied relative to the average darkness of the patch.

18. (Currently Amended) A decoding method, as in claim 2, wherein determining one out of N GCRs ~~N-GCRs~~ comprises:

determining one region of said input that was processed with each GCR; and

for each region:

computing $\beta(n,K_L,L) = E(K_H \mid K_L, L, GCR=n)$;

determining β that is the closest to K_H;

creating a threshold $\tau(K_L,L)$ = ~~(½)~~$[\beta(1, K_L, L) + [\beta(2, K_L, L)]^{(1/2)}$; and

comparing K_H to threshold $\tau(K_L, L)$.

19. (Original) A decoding method, as in claim 1, wherein K_H is evaluated conditional to the average said obtained color value of the decoding region, RGB.

20. (Original) A decoding method, as in claim 19, further comprising deriving from said RGB data the values of K_H, R, G, B, wherein K-colorant amount, K_H, is estimated from a high resolution scan, and R, G, and B are estimated from a down-scaled image, respectively.

21. (Currently Amended) A decoding method, as in claim 19, wherein estimating one out of N-GCRs comprises:

determining one region of said input that was processed with each GCR; and

for each region,

computing $\beta(n,R,G,B)$ ~~□(n,R,G,B)~~ = E(~~KH~~ K_H | R,G,B, GCR=n);

determining β that ~~□ that~~ is the closest to ~~KH~~ K_H;

creating a threshold $\tau(R,G,B)$ ~~□(R,G,B)~~ = $[\beta(1, R,G,B) + [\beta(2, R,G,B)]^{(1/2)}$ ~~(1/2)[□(1, R,G,B) + [□(2, R,G,B)]~~; and

comparing ~~KH~~ K_H to threshold $\tau(R,G,B)$ ~~□(R,G,B)~~.

22. (Original) A decoding method, as in claim 1, wherein determining said GCR is accomplished by processing said estimated K-colorant amount, K_H, and said color value through a look-up table.

23. (Original) A decoding method, as in claim 22, wherein the look-up table has as inputs a transformation of scanner values.

24. (Original) A decoding method, as in claim 23, wherein the look-up table has output the estimated K-colorant amount for each of *N* possible GCR strategy, K_1, K_2, …, K_N.

25. (Currently Amended) A decoding method, as in claim 24, wherein estimating the GCR comprises:

mapping the average scanned color of the region of interest through the lookup table to obtain K estimates for each possible GCR function, $\underline{K_1, K_2, \ldots, K_N,}$ ~~K1, K2, …, KN,~~ for N GCR ~~N GCR~~ strategies;

comparing the K-colorant amount estimated from the region of interest, ~~KH~~ $\underline{K_H}$, to each of the said K estimates from the lookup table mapping; and

selecting the GCR function whose K estimate is closest to ~~KH~~ $\underline{K_H}$.

26. (Currently Amended) A decoding method, as in claim 24, in which two GCR strategies are used wherein the look-up table has as its output the threshold K-colorant value, K_T, for differentiating between the two strategies, which equal $\cancel{\frac{1}{2}}(K_1+K_2)^{\cancel{(1/2)}}$.

27. (Original) A decoding method, as in claim 25, wherein estimating the GCR comprises:

mapping the average scanned color of the region of interest through the lookup table to said obtain K_T;

comparing said estimated K_H for the region of interest to K_T; and

selecting said GCR function corresponding to whether $K_H > K_T$ or $K_H < K_T$.

28. (Original) A decoding method, as in claim 22, wherein an additional output of the look-up table expresses a confidence in the ability to differentiate among the different GCRs for that particular local color.

29. (Original) A decoding method, as in claim 23, wherein an additional input to the look-up table is K_H and wherein the look-up table has as its output a discrete number Q that indicates which GCR was used to print that given scanned pixel.

30. (Original) A decoding method, as in claim 29, wherein the derivation of Q comprises:

dividing the RGBK hyper-cube into N cells;

for every pixel in the image:

finding said pixel's RGBK cell; and

filling in said pixel's Q value; and

for each of said cells:

computing the histogram of the set of said Q values; and

associating said cell with the most popular Q value for that cell.

31. (Original) A decoding method, as in claim 30, wherein estimating the GCR comprises for every pixel in the low resolution image:

computing $RGBK_H$ quadruple;

entering said obtained RGB and said estimated K_H into the cell LUT; and

retrieving Q thereby indicating the GCR estimation.

32. (Currently Amended) A decoding method, as in claim 22, wherein construction of the look-up table comprises:

deriving a set of CMY data;

processing said CMY data through each of said N GCR ~~*N* GCR~~ functions to produce *N* sets of CMYK data;

generating at least one target of patches corresponding to the said *N* sets of CMYK data sets;

printing said at least one target;

scanning said at least one target using the scanner to be used in the decoding of subsequent watermarked images;

for each patch in the scanned image, estimating the amount of K-colorant, K_H, present;

deriving a relationship between a function of said scanned signals and said amount of K_H present for each patch; and

estimating the GCR used for encoding said image region by using the said relationship in conjunction with the said K and average scanned color for the input electronic image.

33. (Original) A decoding method, as in claim 32, wherein the target generation comprises building a separate target for each GCR function.

34. (Original) A decoding method, as in claim 32, wherein the target generation comprises building a single target that includes multi-partite patches, wherein each part of a patch is determined from a different GCR function.